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MVRB #- EA1415-01
NRCan File # - NWT-173

March 10, 2017

Chuck Hubert
Acting Environmental Assessment Manager
Mackenzie Valley Review Board

Re: Natural Resources Canada's Final Submission in relation to the Developer Assessment Report for the Canadian Zinc Corporation Prairie Creek All-Season Road

Dear Mr Hubert,

The Mackenzie Valley Review Board (MVRB) notice of proceeding letter of February 10, 2017 requested parties to submit their Final Submissions on the Canadian Zinc Corporation Prairie Creek All-Season Road Project.

Natural Resources Canada (NRCan) has contributed scientific expertise within our mandate to the MVRB in the areas of explosives storage and permafrost.

NRCan will be attending the Final Hearing in Fort Simpson, NWT from April 26 to April 28, 2017 and will be available to answer questions regarding our final submission.

NRCan is pleased to provide our Final Submission regarding explosives storage and permafrost.

If you have any questions regarding NRCan's Final Submission, please do not hesitate to contact me at 343-292-6746 or at Rachelle.Besner2@Canada.ca.

Sincerely,

(original signed by)

Rachelle Besner
Senior Environmental Assessment Officer
Natural Resources Canada

Attachment: (1) NRCan's Final Submission, Prairie Creek All-Season Road

Canada

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Technical Report Submission

Prairie Creek All-Season Road Project EA1415-01

Canadian Zinc Corporation

Natural Resources Canada

Submission to the Mackenzie Valley Review Board

March 10, 2017

Executive Summary

Summary of NRCan's review

Natural Resources Canada (NRCan) conducted a technical review to assess the completeness and technical merit of the information presented in Canadian Zinc's (CZN) Prairie Creek All-Season Road Developer Assessment Report (DAR) April 2015 and the DAR Addendum September 2015 under the *Mackenzie Valley Resources Management Act (MVRMA).*

Explosives

The developer has identified that the project may require magazines for the storage of explosives. The developer has committed to developing an Explosive Management Plan for the project. NRCan may be required to provide a licence under the *Explosive Act*. If a license is required, NRCan will review the Explosive Management Plan to ensure that the proposed explosives magazines comply with federal regulations.

Permafrost

NRCan reviewed the DAR and DAR Addendum to ensure impacts on permafrost from the All-Season Road were considered and mitigation measures were presented for the project design to ensure the integrity of the road infrastructure and minimize environmental impacts. Potential environmental impacts associated with the All-Season Road include a greater footprint and land area disturbed by the project and additional impacts on the ground thermal regime. NRCan notes that the Developer made a number of commitments for the project that will ensure that impacts associated with the All-season road are minimized. NRCan has provided four recommendations for the Developer to include in the detailed design.

The approach taken by the developer with respect to the road design and impact assessment including the level of baseline data collection, terrain mapping and terrain sensitivity analysis appears to be reasonable for the preliminary design stage and NRCan finds the conclusions presented in the DAR and DAR Addendum to be reasonable.

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1. Introduction

Natural Resources Canada (NRCan) conducted a technical review to assess the completeness and technical merit of the information presented in Canadian Zinc's (CZN) Prairie Creek All-Season Road Developer Assessment Report (DAR) April 2015 and the DAR Addendum September 2015 under the *Mackenzie Valley Resources Management Act (MVRMA).*

1.1. NRCan Mandate

NRCan seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. We are an established leader in science and technology in the fields of energy, forests, and minerals and metals and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of our landmass. NRCan develops policies and programs that enhance the contribution of the natural resources sector to the economy and improve the quality of life for all Canadians. We conduct innovative science in facilities across Canada to generate ideas and transfer technologies. We also represent Canada at the international level to meet the country's global commitments related to the sustainable development of natural resources.

1.2. NRCan's Regulatory Role

NRCan is responsible for administering the *Explosives Act* and regulations, and pursuing the advancement of explosives safety and security technology. Our principal priority is the safety and security of the public and of all workers involved in the explosives industry in Canada. Through the Explosives Regulatory Division (ERD), NRCan provides services and support to the explosives industry, including manufacturers, importers, and distributors, of explosives.

1.3. NRCan's Participation in the Review of the Prairie Creek All-Season Road Project

NRCan has been participating in the review of the proposed Prairie Creek All Season Road both in the context of our role as federal department with a regulatory role through the *Explosive Act* in relation to the manufacture and storage of explosives, and as an expert department with expertise in permafrost.

NRCan has participated throughout the review process and has reviewed the DAR and DAR Addendum for permafrost considerations and did not identify any information requests (IRs). NRCan was satisfied that the information presented would be adequate to conduct the technical review. NRCan participated via teleconference in the Technical Meeting which took place between June 13 and June 16, 2016 and did not identify any undertakings or commitments. A second request for IRs was made by the board in September 2016 and NRCan again identified no IRs for the developer.

NRCan has conducted its review of the DAR to assess whether impacts related to NRCan's mandate and areas of expertise have been adequately identified and evaluated.

2. Subjects Reviewed

2.1. Explosives Storage

The DAR indicates that some explosives will be stored along the road and this project component is described as the temporary storage and use of stick-type explosives for construction. The developer has committed to developing an Explosive Management Plan as part of their commitments presented after the Technical Meeting. As a result, NRCan may be required to issue a license under the *Explosive Act*.

2.1.1. Introduction

NRCan has reviewed information provided in the DAR, DAR Addendum and supporting documentation with respect to the storage of explosives and has concluded that the Developer or an explosives supplier will be required to apply for a license under the *Explosives* Act for the storage of explosives.

2.1.1.1. Summary of NRCan review

NRCan has reviewed the description of explosives storage under section 13: Potential Accidents and Malfunctions in the DAR and concluded that there is sufficient information provided on potential accidents and risks. NRCan does not regulate the use of explosives, which was also described in this section and therefore cannot comment on potential effects.

2.1.1.2. Recommendations

NRCan is satisfied with the explosives storage information provided. Any applications submitted to NRCan's Explosives Regulatory Division for the storage of explosives will require more detailed information (i.e., type of magazine, location of explosives storage, and safety and security measures), if the project is approved.

2.1.1.3. Documents reviewed

Developer's Assessment Report (Apr 2015), All Season Road Project Prairie Creek Mine

Developer's Assessment Report Addendum (Sep 2015)

2.2. Permafrost

2.2.1. Introduction

Canadian Zinc Corporation (CZN) has submitted a proposal, outlined in its Developer's Assessment Report (DAR) to the Mackenzie Valley Review Board (MVRB) for the construction, operation and maintenance of an all season road approximately 170 km long. This road would allow haulage of mineral concentrate out of the Prairie Creek mine site as well as supplies into the mine site throughout the year. The original and approved project description included a winter access road. The proposed all season road roughly follows the alignment of the approved winter road, with some realignment, as described in the DAR and supporting documents. However, there is potential for environmental impacts that were not predicted in the environmental assessment for the original approved project. Additional impacts associated with upgrading of the road for all season use can include for example, a greater foot print and land area disturbed by the project due to clearing for a wider right-of-way and an increased need for granular resources for road embankment construction and maintenance. Additional impacts on the ground thermal regime, resulting in permafrost thaw, changes in drainage and ground instability, may occur through disturbance of the organic mat, or changes in snow cover distribution due to the embankment. NRCan notes that CZN made a number of commitments for the approved project that will also ensure that impacts associated with the all season road are minimized.

The approach taken by the Developer with respect to the road design and impact assessment including the level of baseline data collection, terrain mapping and terrain sensitivity analysis appears to be reasonable for the preliminary design stage. Their approach is consistent with that taken for other recent approved projects such as the Inuvik to Tuktoyaktuk Highway and the road associated with the NICO mine project. Their approach is also consistent with the recommended guidelines for infrastructure and road design in permafrost regions (e.g., CSA 2010, TAC 2010).

A list of commitments is provided in Table B of the DAR (V.1) of which a number are relevant with respect to the impacts of road construction and operation on the surrounding terrain and permafrost. In particular, disturbance to the ground surface in ice-rich thaw sensitive terrain is to be avoided and cut slopes in thaw sensitive terrain are to be avoided (DAR V. 1, sec. 11, App. 1). The Developer recognises that avoiding disturbance to the ground surface may not always be possible and has proposed measures to mitigate the effects. NRCan is in agreement with these commitments and the Developer's approach as maintenance of the organic layer is critical to minimizing impacts on the ground thermal regime and the potential for thawing, changes in drainage and ground instability (see for example Smith et al. 2008, 2015). The Developer has also committed to development of a road maintenance program at the detailed design stage (DAR sec. 15).

With appropriate design, including the various commitments made by CZN, it is NRCan's view that environmental effects associated with the construction and operation of the all season road can be minimized. NRCan does offer a few comments and recommendations below for the Developer's and MVRB's consideration for the detailed and final design of the project or subsequent monitoring and follow up plans.

Documents reviewed

The review focussed on aspects of the project related to permafrost and terrain stability issues. The following documents were considered in the review.

- Developer's Assessment Report (Apr 2015), All Season Road Project Prairie Creek Mine – Vol. 1,2,3 including Appendix 1,2,3,4,8
- Developer's Assessment Report Addendum (Sep 2015) – including Appendix A, B, D, E, F
- Reasons for Decision on the Adequacy of the Developer's Assessment Report, Prairie Creek All Season Road Project – EA1415-01 (Dec 2015)
- Tetratech EBA Mapping Summary Report Proposed Prairie Creek Mine All Season Road Northwest Territories (Dec 2015)
- CZN letter to MVEIRB re: DAR adequacy (Jan 2016)
- CZN response to outstanding adequacy items (Apr 2016)
- Response to Information Requests (May 2016)
- Response to Undertakings (Aug 2016)
- Phase 2 Risk Assessment Technical Report Prairie Creek All Season Road – Oboni Riskope submitted to MVRB (Nov. 2016)
- Terms of Reference for the Prairie Creek All Season Road and Airstrip EA1415-01 (2014)

In addition, consideration was also given to documents relevant to the approved winter road, submitted as part of the DAR for the Prairie Creek Mine Project and MVEIRB's Decision Report.

2.2.2. Issue- Permafrost and draining conditions in project area

References

Terms of Reference for the Prairie Creek All Season Road and Airstrip EA1415-01, section 7.3

DAR V. 1 and App. 1, 2; DAR Addendum including App.F; Tetratech EBA Mapping Summary Report.

An understanding of the permafrost distribution and drainage conditions, and how these may change in response to road construction and operation, is important to ensure that the road performs adequately and to also minimize the impacts on the terrain and permafrost. Changes to drainage for example can occur due to the diversion of cross drainage by the embankment and through permafrost thawing beneath the right-of-way and subsequent settlement and ponding of water. Also, earlier freeze-back of the active layer beneath the embankment can block shallow subsurface flow originating upslope of the embankment that can result in icings which can present a road hazard as well as a buildup of ice adjacent to the embankment and ponding of water during spring melt which can have further impacts on permafrost.

2.2.2.1. Developer conclusions

The Developer has identified areas where permafrost is likely to occur, characterized the potential for thaw sensitive permafrost, and identified areas where there is seepage and cross drainage (e.g. DAR sec. 11, App. 2, DAR Addendum App. F, Tetratech EBA Mapping Summary Report). The Developer concludes that with implementation of measures to limit permafrost thawing and careful placement of culverts, impacts on permafrost and drainage can be minimized (e.g. DAR sec. 11.1, DAR Addendum App. F).

2.2.2.2. NRCan Conclusions and rationale

In NRCan's view, the Developer has done a reasonable job to identify areas along the route likely to be underlain by permafrost with permafrost more likely on north facing slopes. The Developer also indicates that permafrost is more likely to occur at higher elevations (e.g., DAR Addendum App. F). However, the permafrost distribution in areas with significant relief is complex, and the potential for air temperature inversions and cold air drainage can result in colder conditions and permafrost in the valley bottom compared to higher elevations, particularly below treeline, as observed in the Yukon and Mackenzie Valley (Lewkowicz et al. 2011; Taylor et al. 1998). This can result in permafrost occurrence in the valley bottoms but absence on the valley sides. In the central Mackenzie Valley near Norman Wells, springs have been observed in the valley bottom which are likely related to ground water discharge through taliks, from higher elevations in the mountains where permafrost is absent and these are associated with icing formation in winter as has been observed where cross drainage occurs along the pipeline right-of-way (Taylor et al. 1998; Smith and Burgess 2010). The Developer has not noted any naturally occurring icings in the valley bottom that might be associated with subsurface water originating where permafrost is absent at higher elevations except for a water crossing in the Sundog Basin at 23.5 km that is likely associated with groundwater flow (e.g. DAR, V. 1, p. 78).

NRCan notes that with construction of the embankment and colder ground conditions occurring beneath the centre of the embankment, subsurface flow that may originate at higher elevations could be obstructed in the winter due to freezing of the aquifer beneath the embankment and result in icing formation (TAC, 2010). There may be potential for this to occur along the road as

seepage, wet areas and springs have been observed and noted by the Developer (e.g., DAR V. 1 Fig. 4.6, DAR Addendum App. F). NRCan suggests that as design progresses, field investigations could include further identification of areas where obstruction of cross flow and icing formation during the winter might present issues for both road operation and also potential impacts on the surrounding terrain.

2.2.2.3. Recommendations

NRCan recommends that field investigations to be conducted in support of detailed design, also include identification of areas where obstruction of cross flow and icing formation during the winter may be an issue in order to inform the development of management plans to mitigate impacts on road operation and the surrounding terrain.

2.2.2.4. Documents reviewed

References

Lewkowicz, A.G., Bonnaventure, P.P., Smith, S.L., and Kuntz, Z. 2012. Spatial and thermal characteristics of mountain permafrost, northwest Canada. Geografiska Annaler: Series A Physical Geography, 94: 195-215.

Smith, S.L., and Burgess, M.M. 2010. Long-term field observations of cyclical and cumulative pipe and ground movements in permafrost terrain, Norman Wells Pipeline, Northwest Territories Canada. In GEO2010, 63rd Canadian Geotechnical Conference and the 6th Canadian Permafrost Conference. Calgary, Sept. 2010. GEO2010 Calgary Organizing Committee, pp. 595-602.

Taylor, A.E., Nixon, M., Eley, J., Burgess, M., and Egginton, P. 1998. Effects of atmospheric inversions on ground surface temperatures and discontinuous permafrost, Norman Wells, Mackenzie valley, Canada. In Proceedings of the 7th International Conference on Permafrost. Edited by A.G. Lewkowicz and M. Allard. Yellowknife. June 1998. Collection Nordicana, Vol.57, pp. 1043-1047.

2.2.3. Issue- Permafrost and Thaw Sensitivity Characterization in the Project Area

References

Terms of Reference, section 7.3

DAR V. 1 and App. 1, 2; DAR Addendum including App.F; Tetratech EBA Mapping Summary Report; CZN response to adequacy report

Permafrost is an important consideration in the design of roads in northern Canada. Where permafrost is ice-rich and thaw sensitive, warming and thawing due to alteration of the ground thermal regime associated with construction and operation of the road or climate change can result in ground instability and ponding of water which has implications for integrity of the road and the surrounding environment. Adequate knowledge of permafrost conditions is therefore required to support route selection, road design and assessment of impacts.

2.2.3.1. Developer conclusions

The Developer has used a combination of existing surficial geology maps, air photo interpretation and field investigations including digging of test pits and drilling of shallow boreholes to characterize permafrost and terrain conditions in the project area (e.g., DAR V. 1 sec. 11, App. 2, DAR Addendum App. F, Tetratech EBA Mapping Summary Report). This analysis has facilitated identification of sensitive terrain and informed the preliminary road design and the assessment of environmental impacts. Although this level of analysis is adequate at this stage of the design process, the Developer has indicated that detailed site investigations will be required in sensitive areas to determine geotechnical design parameters and optimize the design (e.g., DAR V. 1, Sec 12, CZN response to adequacy report).

2.2.3.2. NRCan conclusions and rationale

NRCan generally agrees that the characterization of permafrost and terrain conditions is adequate for this stage of the design process and that the approach is consistent with that utilized for other recent approved projects in the Northwest Territories (NWT) and outlined in guidelines documents (e.g., CSA, 2010; TAC 2010). NRCan also agrees that additional site investigations may be required in sensitive terrain, on slopes and at water crossings including where major structures may be constructed. Specific sections of the road alignment have been identified by the Developer where further investigations during detailed design will be required to confirm if permafrost is present and/or monitoring to assess changing conditions including: the west end of the Polje Re-route (km 48.8-51); km 40-46; km 53.5-59.9; km 91-94.2; km133.7-134.7 (Tetratech EBA Mapping Summary Report; DAR Addendum App. F)

It is not clear at this stage what the site investigations might involve but NRCan assumes (or suggests) that deeper boreholes might be useful in better characterizing the permafrost and ground ice conditions in particularly sensitive areas including approaches to water crossings and areas where slope instability and creep may be an issue. The Developer mentions with respect to km 53.7-54.2 that probing is required to confirm permafrost presence in this section. Given that there are some limitations to probing; NRCan suggests that the Developer might consider utilizing geophysical surveys in problematic sections to identify frozen ground and also to assess ground ice conditions. Preservation of geotechnical boreholes and installation of temperature cables in sensitive areas is also suggested as this would support further quantitative analysis during detailed design to determine how ground thermal conditions may change over time as

well as supporting assessments of granular resource needs and slope stability assessments. For sensitive slopes, installation of slope inclinometers might also be included in the monitoring program.

2.2.3.3. Recommendations

NRCan recommends that additional site investigations be carried out to confirm permafrost and subsurface conditions including ground ice conditions, particularly in areas of sensitive terrain (including slopes) or where major structures are planned in order to support final design and also to inform development of mitigation, management and monitoring plans. NRCan also recommends that some of the techniques mentioned above including deeper geotechnical boreholes, installation of temperature cables, geophysical surveys and installation of slope inclinometers would be useful components of the detailed site investigations to characterize permafrost conditions and also support quantitative analysis during detailed design and to form part of the ongoing monitoring and management plans.

2.2.3.4. Documents reviewed

References

Canadian Standards Association (CSA) 2010. Technical Guide - Infrastructure in permafrost: a guideline for climate change adaptation, Report Plus 4011-10.

Transportation Association of Canada (TAC) 2010. Guidelines for development and management of transportation infrastructure in permafrost regions, Ottawa

2.2.4. Issue- Analysis to determine impacts of the project on permafrost, including effects of climate change

References

Terms of Reference, sections 7.3, 8

DAR V. 1 and App. 1, 2; DAR Addendum including App.F; Tetratech EBA Mapping Summary Report.

Understanding the permafrost-infrastructure interaction is an important consideration for appropriate design of northern infrastructure. Construction and operation of infrastructure can lead to alteration of the ground thermal regime and thawing of permafrost which may have implications for ground instability and drainage which can affect the integrity of infrastructure and the surrounding environment. Climate change presents an additional challenge and long-term warming can result in additional thaw of permafrost. Assessment of how permafrost conditions

may change over time is therefore required to evaluate the impact of the project on the environment and also the impact of the environment on the project.

2.2.4.1. Developer conclusions

The Developer acknowledges that permafrost conditions may change over time due to road construction and operation and that climate change may further enhance thawing of permafrost (e.g., DAR V. 1 sec. 11, 12, App. 2). They have identified areas that are likely to be thaw sensitive and with implementation of appropriate design and mitigation techniques they conclude that impacts can be minimized (e.g., DAR V.1 Table B, App. 1, 2; DAR Addendum App. F; Tetratech EBA Mapping Summary Report) .

2.2.4.2. NRCan Conclusions and rationale

NRCan generally agrees with the Developer's approach and they have used the screening tool outlined in CSA (2010) to determine the vulnerability of the project to climate change and the level of the analysis that is required. This screening indicates a higher risk for thaw sensitive permafrost terrain including areas where major structures are planned while the risk is lower where frost stable permafrost is present. Qualitative analysis and expert judgement are sufficient to support project design for low risk areas while quantitative analysis is required for high risk areas (DAR V. 1, sec. 12). NRCan agrees that quantitative analysis to assess changing permafrost conditions and to support slope stability analysis is required for areas identified as high risk including slopes and where major structures are planned. At this stage of the project design, it appears that only qualitative assessments of the amount of thaw that may occur, including the effect of climate change, over the project life have been conducted. NRCan would note however, that in their qualitative analysis of the impacts of climate change, the Developer has taken a conservative approach to support their impact analysis as they consider that changes in ground temperature will occur in step with changes in air temperature. The Developer does however acknowledge that quantitative analysis should be conducted for areas where permafrost is thaw sensitive (high risk) in order to optimize design (DAR V. 1. Sec. 12, App. 2).

NRCan suggests that quantitative analysis (e.g., thermal modelling) would benefit the detailed design for thaw sensitive and high risk sections of the route. This would enable better assessments of changing permafrost conditions, including the amount of thaw and settlement that might occur over the project life. This would also facilitate estimates of granular resources required for ongoing maintenance of the road. Analysis that includes 2-D thermal modelling would also allow a better assessment of the extent of impacts on terrain associated with both vegetation clearing and climate change especially since these effects on the ground thermal regime can extend beyond the cleared right-of-way as has been shown for the Norman Wells pipeline right-of-way (Smith and Riseborough 2010). This analysis could therefore support mitigation and management decisions. Thermal analysis would also be required to support slope stability and creep analysis that might be required for problematic areas (e.g., Tetratech EBA

Mapping Summary Report). NRCan does agree with the Developer's suggestion (DAR V. 1, sec. 12) that more detailed site investigations including deeper boreholes, and information collected using other techniques such as those suggested in Issue 2, will be required to determine the geotechnical design parameters required for the quantitative analysis.

2.2.4.3. Recommendations

NRCan recommends that during the detailed design stage, that for high sensitivity areas, the Developer conduct quantitative analysis which may include thermal modelling to better assess how permafrost conditions might change, including the effects of climate change. This analysis should incorporate additional information from detailed site investigations, and be used to refine design and impact assessment, to support slope stability analysis and to determine borrow requirements for long-term maintenance and to inform monitoring and mitigation plans.

2.2.4.4. Documents reviewed

References

Canadian Standards Association (CSA) 2010. Technical Guide - Infrastructure in permafrost: a guideline for climate change adaptation, Report Plus 4011-10.

Smith, S.L., and Riseborough, D.W. 2010. Modelling the thermal response of permafrost terrain to right-of-way disturbance and climate warming. Cold Regions Science and Technology, 60: 92-103.

3. Overall conclusion

NRCan is generally satisfied with the information provided, and, within the context of the department's areas of expertise, finds the conclusions presented in the DAR and DAR Addendum to be reasonable.

NRCan appreciates the opportunity provided by the Mackenzie Valley Impact Review Board to participate in this review. We would be pleased to answer any questions regarding our comments from the Board, its staff, the Developer, or other Parties to this review.

4. Summary of NRCan's recommendations for Canadian Zinc Corporation

4.1. Permafrost recommendations

1. NRCan recommends that field investigations be conducted in support of detailed design and include identification of areas where obstruction of cross flow and icing formation during the winter may be an issue.

2. NRCan recommends that additional site investigations be carried out to confirm permafrost and subsurface conditions including ground ice conditions, particularly in areas of sensitive terrain (including slopes) or where major structures are planned in order to support final design and also to inform development of mitigation, management and monitoring plans.

3. NRCan recommends that some of the techniques, including deeper geotechnical boreholes, installation of temperature cables, geophysical surveys and installation of slope inclinometers would be useful components of the detailed site investigations to characterize permafrost conditions and also support quantitative analysis during detailed design and to form part of the ongoing monitoring and management plans.

4. NRCan recommends that during the detailed design stage, that for high sensitivity areas, the Developer conduct quantitative analysis which may include thermal modelling to better assess how permafrost conditions might change, including the effects of climate change. This analysis should incorporate additional information from detailed site investigations, and be used to refine design and impact assessment, to support slope stability analysis and to determine borrow requirements for long-term maintenance and to inform monitoring and mitigation plans.

5. In the event that an *Explosive Act* permit is required from NRCan, the developer or its explosive supplier will be required to submit an application for the explosive manufacturing and storage facilities associated with the construction of the Prairie Creek All-Season Road project. Information required would include the types and maximum quantities of explosives, storage plans, liquid effluent plans, spill contingency plans, and security plans. The explosives supplier will need to comply with permit conditions, guidelines and standards.